

**REMARKS**

Claims 74-80, 82 and 83 are pending in this application.

The drawings stand objected to as “the . . . copper layer containing a copper oxide layer thereon . . . must be shown or the feature(s) canceled from the claim(s).” (Office Action at 2). The Office Action notes that “FIG. 8 shows a copper oxide layer; however, it does not show the titanium-aluminum-copper-nitrogen layer formed over at least an upper surface of said copper layer and the copper oxide layer.” ( Office Action at 2).

Applicant notes that Figure 8 is a schematic representation of how copper oxidizes in air. Figure 8 was submitted by Applicant to allow a better understanding of how copper oxidation is suppressed by the introduction of implanted titanium ions. Applicant notes that a copper native oxide layer is not illustrated in any of the other figures of the claimed invention, as it is a native, inherent component of a copper layer having a minimal thickness and being integral with the copper layer. As emphasized in the specification, the “oxide film 36 [of Figure 8] is a result of the formation of native oxide Cu<sub>2</sub>O on copper bond surface 34” (¶[0046]). As “[s]ufficient evidence exists to support the conclusion that, to the extent it was necessary, the drawings were sufficient for a skilled artisan to understand the subject matter of the claimed invention” and as “[a]ny structural detail that is of sufficient importance to be described [has been] shown in the drawings,” Applicant believes that no drawing amendment is necessary. *See In re Hayes Microcomputer Products Inc. Patent Litigation*, 982 F.2d 1527,1536 (Fed. Cir. 1992); *Ex parte Good*, 1911 C.D. 43 (Comm'r Pat. 1911).

Claims 74-78 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Harada et al. (U.S. Patent No. 5,565,378) ("Harada") in view of Hsiao et al. (U.S. Patent No. 5,985,765) ("Hsiao"). This rejection is respectfully traversed.

The claimed invention relates to a copper bond pad for a semiconductor device. As such, independent claim 74 recites a "copper bond pad" comprising *inter alia* "a dielectric layer formed over a substrate," "a barrier layer formed over said dielectric layer" and "a copper layer formed over said barrier layer, said copper layer having an upper surface implanted with titanium, said copper layer having a thickness of about 500 Angstroms to about 20,000 Angstroms." Independent claim 74 also recites "an insulating layer over said copper layer."

Harada relates to a "passive state film . . . formed on a surface of a bonding pad." (Abstract). Harada teaches that "silicon substrate 71 is immersed in solution continuously supplied with ozone." (Abstract). In this manner, "[s]ince ozone is continuously supplied, it is possible to maintain the concentration of the dissolved ozone in the solution above a predetermined concentration." (Abstract).

Hsiao relates to a "method for reducing bonding pad loss . . . using a capping layer when contact openings are etched to the bonding pads, while concurrently etching much deeper fuse openings to the substrate." (Abstract). According to Hsiao, "[b]onding pads are used on the top surface of integrated circuit semiconductor chips to provide external electrical connections for I/Os and power." (Abstract). Hsiao also teaches that the "invention uses a novel process in which a capping layer, having a low etch rate, is formed on the bonding pads to prevent overetching while the fuse openings are etched to the desired depth in the thicker insulating layers." (Abstract).

The subject matter of claims 74-78 would not have been obvious over Harada in view of Hsiao. Specifically, the Office Action fails to establish a *prima facie* case of obviousness. Courts have generally recognized that a showing of a *prima facie* case of obviousness necessitates three requirements: (i) some suggestion or motivation, either in the references themselves or in the knowledge of a person of ordinary skill in the art, to modify the reference or combine the reference teachings; (ii) a reasonable expectation of success; and (iii) the prior art references must teach or suggest all claim limitations. See e.g., In re Dembicza, 175 F.3d 994 (Fed. Cir. 1999); In re Rouffet, 149 F.3d 1350, 1355 (Fed. Cir. 1998); Pro-Mold & Tool Co. v. Great Lakes Plastics, Inc., 75 F.3d 1568, 1573 (Fed. Cir. 1996).

First, Harada and Hsiao, whether considered alone or in combination, do not disclose, teach or suggest all limitations of claims 74-78. Harada fails to disclose, teach or suggest “a copper layer formed over said barrier layer,” much less “a copper layer formed over said barrier layer, said copper layer having an upper surface implanted with titanium,” as independent claim 74 recites. In Harada, film 107 (which would arguably correspond to the “copper layer” of the claimed invention) is an “aluminum alloy film” that includes “aluminum and at least one material selected from the group consisting of copper (Cu), titanium (Ti), chromium (Cr), magnesium (Mg), scandium (Sc), yttrium (Y), zirconium (Zr), hafnium (Hf), vanadium (V), niobium (Nb), tantalum (Ta), molybdenum (Mo), tungsten (W) and palladium (Pd), which is added to the aluminum.” (Col. 6, lines 54-60). Thus, the aluminum alloy film 107 of Harada is not a “copper layer,” as in the claimed invention. Harada is also silent about a “copper layer having an upper surface implanted with titanium” or having “a thickness of about 500 Angstroms to about 20,000 Angstroms,” as independent claim 74 also recites.

Hsiao also fails to disclose, teach or suggest all limitations of claims 74-78. Hsiao is silent about “a copper layer formed over said barrier layer,” much less about “a copper layer formed over said barrier layer, said copper layer having an upper surface implanted with titanium,” as independent claim 74 recites. Hsiao teaches that layer 18 (which would arguably correspond to the “copper layer” of the claimed invention) is “preferably a multilayer composed of a titanium nitride (TiN) layer 18A, an AlCu layer 18B, and a second TiN layer 18C” (col. 4, lines 62-64). Thus, Hsiao fails to disclose, teach or suggest a “a copper layer,” much less about “a copper layer . . . having an upper surface implanted with titanium,” as in the claimed invention.

Second, a person of ordinary skill in the art would not have been motivated to combine Harada with Hsiao to arrive at the claimed invention. Applicants note that, to establish a *prima facie* case of obviousness, “[i]t is insufficient that the prior art disclosed the components of the patented device, either separately or used in other combinations; there must be some teaching, suggestion, or incentive to make the combination made by the inventor.” Northern Telecom, Inc. v. Datapoint Corp., 908 F.2d 931, 934 (Fed. Cir. 1990). This way, “the inquiry is not whether each element existed in the prior art, but whether the prior art made obvious the invention as a whole for which patentability is claimed.” Hartness Int'l, Inc. v. Simplimatic Engineering Co., 819 F.2d 1100, 1108 (Fed. Cir. 1987). Accordingly, a determination of obviousness “must involve more than indiscriminately combining prior art; a motivation or suggestion to combine must exist.” Pro-Mold & Tool Co., 75 F.3d at 1573. This way, a rejection of a claim for obviousness in view of a combination of prior art references must be based on a showing of a suggestion, teaching, or motivation that has to be “clear and particular.” In re Dembiczak, 175 F.3d at 999. Thus, the mere fact that it is possible to find two isolated disclosures which might be combined to produce a new

compound does not necessarily render such production obvious, unless the prior art also suggests the desirability of the proposed combination.

The July 14, 2005 Office Action fails to establish a *prima facie* case of obviousness because, as the Court in Northern Telecom, Inc. noted, “[i]t is insufficient that the prior art disclosed the components of the patented device” and there is no “teaching, suggestion, or incentive to make the combination.” Northern Telecom, Inc., 908 F.2d at 934. On one hand, the crux of Harada is the formation of a passive state film over the bonding pad. For this, Harada specifically teaches that passive state film 87 “is formed on bonding pad 89 with ozone water” and by a specific process according to which “[o]xygen gas is turned into ozone gas by an ozone gas generator 118, to be supplied to a bubbling machine 122 in water tank 117” subsequent to which “[s]ilicon substrate 71 [is] immersed in ozone water 130 for 5-60 minutes.” (Col. 7, lines 35-45).

On the other hand, the crux of Hsiao is the formation of a capping layer, having a low etch rate, which is “formed on the bonding pads to prevent overetching while the fuse openings are etched to the desired depth in the thicker insulating layers.” (Abstract). The capping layer of Hsiao is “preferably composed of tungsten (W), and is deposited by sputter deposition, for example from a W target . . . by CVD.” (Col. 5, lines 11-16). Accordingly, a person of ordinary skill in the art would not have been motivated to combine Harada, which teaches the formation of a passive state film by immersing the substrate in a solution continuously supplied with ozone, with Hsiao, which teaches a capping layer that is employed as an etch stop layer and is formed by a CVD process. For at least these reasons, the Office Action fails to establish a *prima facie* case of obviousness, and withdrawal of the rejection of claims 74-78 is respectfully requested.

Claims 79, 80, 82 and 83 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Jang et al. (U.S. Patent No. 6,423,625) ("Jang") in view of Mahulikar et al. (U.S. Patent No. 5,320,689) ("Mahulikar"). This rejection is respectfully traversed.

The claimed invention relates to an "interconnect structure for a semiconductor die." As such, independent claim 79 recites an "interconnect structure for a semiconductor die" comprising "a conductive bond pad containing a copper layer, said copper layer containing a copper oxide layer thereon." Independent claim 79 further recites "a titanium-aluminum-copper-nitrogen layer formed over at least an upper surface portion of said copper layer."

Jang relates to a method of improving the bondability between gold wires and copper bonding pads. (Title; Abstract). Jang teaches that, to prevent copper oxidation, "with the methods of the present invention, Al or AlCu as a glue and protection layer is implemented on Cu bonding pads for successful Au wiring." (Abstract).

Mahulikar relates to "a composite copper alloy having a copper alloy core and a modified surface layer containing a nitride or carbide film." (Abstract). According to Mahulikar, "the modified surface layer may contain a carbo-nitride film" and "[t]he alloy is formed by reacting a copper alloy with nitrogen, carbon or a nitrogen/carbon mixture at elevated temperatures." (Abstract).

The subject matter of claims 79, 80, 82 and 83 would not have been obvious over Jang in view of Mahulikar. Specifically, the Office Action fails to establish a *prima facie* case of obviousness. Neither Jang nor Mahulikar, considered alone or in combination, discloses, teaches or suggests all limitations of independent claim 79. Jang teaches "Al or AlCu as a glue and protection layer . . . for successful Au wiring,"

and not “a conductive bond pad containing a copper layer, said copper layer containing a copper oxide layer thereon,” much less “a titanium-aluminum-copper-nitrogen layer formed over at least an upper surface portion of said copper layer,” as in the claimed invention.

Mahulikar also fails to disclose any of the limitations of claim 79. Mahulikar does not even teach a “bond pad,” much less “a conductive bond pad containing a copper layer” and having all the limitations recited in claim 79. The crux of Mahulikar is composite alloys that have a specific alloy core and a modified surface layer containing a nitride or carbide film, to improve the corrosion resistance of such alloys, and not bond pads for integrated circuits, much less bond pads having the characteristics of the claimed invention.

Applicant also note that a person of ordinary skill in the art would not have been motivated to combine these disparate references. The crux of Jang is improving the bondability between gold wires and copper bonding pads by providing “Al or AlCu as a glue and protection layer.” (Abstract). In contrast, Mahulikar addresses the corrosion properties of alloys by providing such alloys with a specific alloy core and a modified surface layer containing a nitride or carbide film. Accordingly, there is no motivation for one skilled in the art to combine these disparate references, and withdrawal of the rejection of claims 79, 80, 82 and 83 is also respectfully requested.

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Allowance of the application is solicited.

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